ELECTRONICALLY COMMUTATABLE MOTOR

Field Of The Invention

The present invention relates to an electronically
commutatable motor, whose excitation windings are
controllable via semiconductor output stages by an
electronic control unit with the aid of PWM control
signals. A setpoint value can be specified to the
control unit, and the control unit emits corresponding
PWM control signals to the semiconductor output stages. A
motor characteristic curve, from which an assigned
nominal operating speed is derivable for the setpoint
value is stored in the control unit, and the derived
nominal operating speed can be compared to the actual
speed of the motor. If a predefinable or predefined
speed difference between the nominal operating speed and
the actual speed is exceeded, the control unit and/or the
semiconductor output stages can be switched off.

Background Information

A conventional electronically commutatable motor is
described in German Published Patent Application 198 04
?74. In that case, the PWM control signals are
5   established in their pulse width by the input of the
setpoint value. The comparison of the nominal operating
speed, which is assigned to the setpoint value, to the
actual speed, is used during the continuous running
operation for detecting sharp increases of the setpoint
10   value acting from outside, in order to set the pulse

expenditure of memory in the control unit to ascertain
the allocated nominal operating speed

Storage of the characteristic-curve data of a motor in a memory of the control unit and use of the characteristic-curve data for deriving an operating value is discussed to some extent in the U.S. Patent No. 5,901,286 and European Published Patent Application No. 0 886 057. In these references, a characteristics field having a plurality of value pairs is used, from which the desired nominal operating value can be derived by interpolation onto a third coordinate. However, this requires a considerable expenditure of memory, particularly when the load of the motor changes.

The object of the present invention is to provide a motor of the type mentioned at the outset with simple data in the control unit, which, with minimal expenditure, for a predefined load, significantly simplifies the derivation of the nominal operating speed corresponding to a predefined setpoint value.

Summary Of The Invention

According to the present invention, this objective is achieved by storing the motor characteristic curve only as a three-dimensional characteristics field having four corner points, which, through coordination with the smallest pulse width and the limiting values of the supply voltage, as well as with the largest pulse width and the limiting values of the supply voltage, are determined by the nominal operating speeds assigned in each case. The nominal operating speed for the comparison to the actual speed is derivable as a function of the existing supply voltage, the predefined setpoint

In this context, attention is to be taken of the fact that in many cases, the motor is always loaded with the same

coordinate values of the characteristics field take into
account not only the pulse widths of the PWM control
signals corresponding to the predefinable setpoint
values, but also the fluctuations of the supply voltage,
and define a characteristics field which allows a clear
and simple derivation, i.e. calculation of the assigned
nominal operating speed, for the supply voltage present
in each case and the control conditions, the connecting
lines of the corner points of the characteristics field
giving the stipulations for a grid, and thus facilitating
the derivation of intermediate values in the coordinate
directions for the supply voltage (e.g. x-coordinate) and
the pulse widths (e.g. z-direction), and leading to the
sought nominal operating speed (in the y-direction).

Depending upon the use of the motor, according to a
further embodiment, the four corner points of the
characteristics field may be determined for a predefined
motor load. The motor can then be designed in a simple
manner for a different load, i.e. consumer.

In this context, according to one refinement of the
present invention, the comparison between the nominal
operating speed and the actual speed is able to be
carried out continually during the continuous running of
the motor or repeated at time intervals.

The setpoint value may be specifiable manually in a
simple manner using a potentiometer, the control unit
being able to be supplied with a variable setting signal
which is used for the emission of allocated PWM control

motor characteristic curve and utilized for the
comparison with the actual speed of the motor minus

different ways.

For the comparison of the nominal operating speed and the actual speed, the control unit is coupled to a comparator unit which may be integrated into the control unit.

So that the overload protection does not react to short interference pulses of the actual-speed measurement, one embodiment of the present invention provides for the control unit and/or the semiconductor output stages to be switched off in a time-delayed manner.

If a run-up phase precedes the continuous operation of the motor, then the overload protection may be designed so that the comparison of the nominal operating speed and the actual speed is first able to be initiated and carried out after a run-up phase of a predefined duration has expired, so that an inadvertent shut-down does not occur during this operating phase. The run-up phase may be preset by the control unit, and the amplitude of the pulses and the pulse width of the PWM control signals, as well as their commutation frequency may be used as parameters. The run-up phase of the motor is able to be initiated with the switch-on of the control unit and/or the semiconductor output stages, and/or the input of a setpoint value for the control unit.

Brief Description Of The Drawings
Figure 1 shows a block diagram of the functional units of an exemplary motor according to an embodiment of the present invention.

As the block diagram according to Figure 1 shows, the motor unit includes an electronic control unit STE which is assigned a comparator unit VE. For a desired continuous operation, a correspondingly adjusted setpoint value $N_{setpoint}$ is specified and provided to this control unit STE. Consequently, after a run-up phase, correspondingly dimensioned PWM control signals pwm are emitted to semiconductor output stages EST which energize the excitation windings of motor M according to the pulse widths of these PWM control signals pwm. An actual speed N_{actual} thereupon sets in at motor M that is detected and supplied as a signal to a comparator unit VE which may be integrated into control unit STE. Control unit STE stores a motor characteristic curve which allows the derivation of a nominal operating speed n_x for each setpoint value $N_{setpoint}$. This nominal operating speed n_x is obtained more or less exactly in the case of the predefined setpoint value $N_{setpoint}$ if control unit STE, semiconductor output stages EST and motor M are operating correctly, and no conditions exist which lead to a drop in actual speed N_{actual}.

Nominal operating speed n_x, like actual speed N_{actual}, is supplied to comparator unit VE, and a speed deviation ΔN is ascertained. If actual speed N_{actual} is more than a predefined or predefinable speed deviation ΔN below expected nominal operating speed n_x, then a fault exists which can lead to an overload during continuous operation. Therefore, comparator unit VE generates a switch-off signal AB via which control unit STE and/or semiconductor output stages EST can be switched off, as

If setpoint value $N_{setpoint}$ is changed, then PWM control

speed n_z is supplied to comparator unit VE, and the comparison is carried out in the same manner for the new continuous operation with altered speed.

5   The switch-off of control unit STE and/or of semiconductor output stages EST may also be initiated in a delayed fashion, in order to suppress spurious peaks in the derived and detected speed values.

10   Permissible speed deviation ΔN may also be made a function of the magnitude of predefined setpoint value $N_{setpoint}$ and the existing magnitude of supply voltage u_x. The comparison by comparator unit VE may be carried out continually during the continuous operation, or repeated
15   at time intervals. In addition, the overload protection by the comparison and the shutdown may first be switched to effective after reaching the nominal operating speed specified by the setpoint value, i.e. after a predefined or predefinable run-up time has expired. In this context,
20   the run-up time may be started with the switching-on, that is to say, with the feeding of supply voltage u_x to control circuit STE and/or to semiconductor output stages EST, and/or with the application of a predefined setpoint value $N_{setpoint}$ to control unit STE.
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     Nominal operating speed n_x, derived and calculated by control unit STE, is a function not only of existing supply voltage u_x with its limiting values u_1 and u_2, but also of stored speeds n_{11}, n_{12}, n_{21}, n_{22} of the corner points
30   of characteristics field KF, as the specification $n_x=f(N_{setpoint}, u_1, u_2, n_{11}, n_{12}, n_{21}, n_{22})$ in the Figure

according to Figure 2 shows, the voltage range from u_1 to u_2 is plotted in the x direction, while the pulse

the exemplary embodiment, U_{max} = 13V and U_{min} = 8V are
selected, and the pulse width has a range from
pwm_{min} = 60% to pwm_{max} = 100%. For the smallest supply
voltage, given pwm_{min} = 60% and pwm_{max} = 100%, nominal
operating speeds of n_{11} = 50 min^{-1} and n_{21} = 1800 mm^{-1}
result, while for the greatest supply voltage, given
pwm_{min} = 60% and pwm_{max} = 100%, nominal operating speeds
n_{12} = 150 min^{-1} and n_{22} = 2900 min^{-1} result. These nominal
operating speeds n_{11} to n_{22} define the four corner points
P1 to P4 in three-dimensional characteristics field KF.
The connecting lines between corner points n_{11} and n_{21}, n_{11}
and n_{12}, n_{21} and n_{22}, and n_{12} and n_{22}, respectively, permit
the formation of a grid which, for existing supply
voltages U_x and pulse width pwm_x corresponds to a setpoint
value. Formation of the grid allows the derivation of
allocated nominal operating speeds n_x on straight line $n1_x$
- $n2_x$. Thus, given a supply voltage of U_x = 10.5V and a
pulse width of approximately 87%, a nominal operating
speed of approximately 1800 min^{-1} can be interpolated from
characteristics field KF.

This characteristics field KF is valid for a specific
motor for a predefined, constant load. For a further
load, a characteristics field KF valid for the further
load can be stored in control unit STE.

As the three-dimensional characteristics field KF
according to Figure 2 shows, supply voltage u_x having the
voltage range from smallest supply voltage u_1 = 8V to
greatest supply voltage u_2 = 13V is plotted in the
x-direction. In the z-direction, pulse width pwm of the
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Limit operation cases are ascertained with u_1 and pwm_1, u_1
and pwm_2, u_2 and pwm_1, as well as u_2 and pwm_2, which load

consequently define characteristics field KF according to Figure 2.

If motor M is loaded with a different load, then a similar characteristics field KF results having new nominal operating speeds n_{11}, n_{12}, n_{21} and n_{22}.

The following values result for characteristics field KF of an exemplary embodiment shown in Figure 2:

$n_{11} = 50$ min^{-1} at $u_1 = 8V$ and $pwm_1 = 60$ %

$n_{12} = 150$ min^{-1} at $u_2 = 13V$ and $pwm_1 = 60$ %

$n_{21} = 1800$ min^{-1} at $u_1 = 8V$ and $pwm_2 = 100$ %

$n_{22} = 2900$ min^{-1} at $u_2 = 13V$ and $pwm_2 = 100$ %

Characteristics field KF can be represented as a grid, the connecting lines between corner points n_{11} and n_{12}, and n_{21} and n_{22}, respectively, as well as n_{11} and n_{21}, and n_{12} and n_{22}, respectively, specifying the gridding, and as is shown, for an existing supply voltage u_x, permitting the derivation of allocated nominal operating speed n_x in the case of existing PWM control signal p_x. PWM control signal pwm_x is allocated to predefined setpoint value $N_{setpoint}$.

As grid line $nx_1 - nx_2$ shows, in the case of $u_x = 10.5V$ and a pulse width of $pwm_x - 87.5$%, the derivation of nominal operating speed n_x leads to a value of approximately 1800 min^{-1}.

To calculate nominal operating speed n_x allocated to a setpoint value $N_{setpoint}$, one proceeds as follows with

$$stg1 = \frac{n_{12} - n_{11}}{u_2 - u_1} \qquad\qquad stg2 = \frac{n_{} - n_{}}{u_{} - u_{}}$$

$$n_{1x} = n_{11} + stg_1 * (u_x - u_1)$$
$$n_{2x} = n_{21} + stg_2 * (u_x - u_1)$$

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$$stg_3 = \frac{n_{2x} - n_{1x}}{pwm_2 - pwm_1} = \frac{n_{21} - n_{11} + (stg_2 - stg_1) * (u_x - u_1)}{pwm_2 - pwm_1}$$

Thus,

$$\boxed{n_x = n_{1x} + stg_3 * (pwm_x - pwm_1)}$$

10 Since the calculations use the reciprocal of the speed values, the above equation for calculating surface point n_x must be changed around accordingly. With $T_x = a/n_x$, it follows that:

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$$\frac{a}{T_x} = n_{1x} + stg_3 * (pwm_x - pwm_1)$$

$$T_x = \frac{a * (pwm_{} - pwm_{})}{(((\cdots) * u \cdots \cdots) * pwm \cdots (pwm * \cdots \cdots pwm * \cdots) * u \cdots pwm * (n \cdots \cdots u * \cdots) \cdots pwm * (\cdots * u}$$

width of output-stage control pwm$_x$ are variable. The
remaining factors may be stored as fixed parameters in
the ROM or EEPROM. Following is once again the same
formula with the variable names used in the program code.

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$$v\_tx = \frac{K\_ZAEHL_1}{\left(\left(K\_NENN_1 * v\_ubat + K\_NENN_2\right) * v\_pwm\_endst + K\_NENN_3 * v\_ubat + K\_NENN_4\right)}$$

During the programming at the rear end of the assembly

10   line, the corresponding parameters can now be transferred
from the test stand into the EEPROM of the motor control.

Wherein:

$$K\_NENN_1 = \left(stg_1 - stg_2\right)$$

$$K\_NENN_2 = -n_{21} + n_{11} + \left(stg_2 - stg_1\right) * u_1$$

$$K\_NENN_3 = \left(pwm_1 * stg_2 - pwm_2 * stg_1\right)$$

$$K\_NENN_4 = pwm_1 * \left(n_{21} - u_1 * stg_2\right) + pwm_2 * \left(stg_1 * u_1 - n_{11}\right)$$